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FEATURE ARTICLE

Making the Unaware Aware: Surface Electromyography to Unmask Tension and Teach Awareness

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Poor awareness of covert low-level muscle tension and poor ergonomics can result in chronic muscle bracing and the development of clinical symptoms. This article introduces a simple exercise to teach awareness and control of residual muscle contraction, presents evidence of its effectiveness, and concludes with a case study in which this exercise contributed to the treatment of severe pelvic girdle pain. The authors warn against becoming "captured" by tasks and adjusting to bad ergonomics, and emphasize the importance of enhancing somatic awareness to correct dysponesis before it results in pain and disability.

You only have to think to lift the hand and the muscles react.

I did not realize that muscle tension occurred without visible movement.

I was shocked that I was unaware of my muscle activity—the EMG went up before I felt anything.

Just anticipating the thought of the lifting of my hand increased the EMG numbers.

After training I could feel the muscle tension and it was one third lower than before I started.

—Workshop participants after working with SEMG feedback

Background

Until they experience stiffness or pain, many people are totally unaware that they are tightening their muscles and continuously holding slight tension without relaxing. This covert low-level muscle tension can occur in any muscle and has been labeled dysponesis, namely, misplaced and misdirected efforts (from the Greek: *dys* = bad; *ponos* = effort, work, or energy) (Harvey & Peper, 2012; Whatmore & Kohli, 1974). This chronic covert tension is a significant contributor to numerous disorders that range from neck, shoulder, and back pain to headaches and exhaustion. People are usually unaware of their muscle tension or autonomic arousal (Shumay & Peper, 1997; Stein, Schäfer, & Machelska, 2003).This process is commonly observed in people working at the computer. While mousing and during data entry, most are unaware that they are slightly tightening their shoulder muscles (trapezius and anterior deltoid muscles). For example, typing with a tilt angle of 100° produces higher cervical and shoulder discomfort than typing at an angle of 130° (Chiou, Chou, & Chen, 2012). One can often see this low-level chronic tension when a person continuously lifts an index finger in anticipation of clicking the mouse or bends the wrist and lifts the fingers away from the keyboard while mousing with the other hand as shown in Figure 1. In the long run, dysponesis or unawareness of musculoskeletal tension and discomfort may influence quality of life and cause psychosomatic symptoms (del Pozo-Cruz et al., 2013; Fujii, Matsudaira, Yoshimura, Hirai, & Tanaka, 2013).

People may hold a position for a long time without being aware that they are contracting their muscles. They tend to be unaware of what is happening inside their body since they are focusing on their task performance. They are "captured by the screen" until discomfort and pain occur. Only after they experience discomfort or pain, do they change position.

Factors that contribute to this apparent lack of somatic awareness include:

- Being captured by the task. People are so focused upon performing a task that they are unaware of their dysfunctional body position, which eventually will cause discomfort.
- Institutionalized powerlessness. People accept the external environment as unchangeable (functional fixedness),

Figure 1. Lifting the hand without any awareness while mousing with the other hand.

they cannot conceive new options, and do not attempt to adjust the environment to fit it to themselves.

- Lack of somatic awareness and training. People are unaware of their own low levels of somatic and muscle tension.

Being Captured by the Task

People often want to perform a task well and they focus their attention upon correctly performing the task. They begin the task without regard for themselves and forget to check whether their body position is optimized for the task. Only after the body position becomes uncomfortable and interferes with task performance, do they become aware. At this point, the discomfort has often transformed into pain or illness.

This process of immediately focusing on task performance is easily observed when people are assigned to perform a new task. For example, you can ask people who are sitting in chairs arranged by row to form discussion groups to share information with the individuals in front or behind them. Some will physically lift and rotate their chair to be comfortable, while others will rotate their body without awareness that this twisted position increases physical discomfort. As instructors, we often photograph the participants as they are performing their tasks as shown in Figure 2.

Even when the chairs could be moved, only one-third of the participants moved their chairs while the other two thirds rotated their bodies. In almost all cases, they were unaware that they did this and that they were creating discomfort. When the exercise was finished, they were shown the photographs of how they had twisted their bodies. They were surprised by this visual feedback since they were unaware of what they had done or the choices they had made. The photographs provided useful feedback about their choices and how they were unaware of their own bodies. This concept of lack of awareness is important because many people just use the provided furniture for their computer use. When students used computers without furniture specifically designed for computer use at home, they had more musculoskeletal discomfort. Students without proper furniture were more likely to have musculoskeletal pain (Jacobs & Baker, 2002). This discomfort can be reduced or eliminated by training. For example, Robertson and O'Neill (2003) developed an ergonomics workplace and training program and found a significant increase in workers' office ergonomics knowledge and awareness, improvement in their work environment, increased productivity, and reduced musculoskeletal discomfort.

Institutionalized Powerlessness

To change the environment requires self-worth and the willingness to initiate action. People who adjust themselves instead of modifying the environment need to learn to pause before diving into a task. They need to ask, "What do I need to do to make the environment fit for me?" To take this initiative is challenging, since many people have covertly learned to be powerless. They fear that if they change the environment, someone will object. In many large organizations, no one wants to take responsibility to give permission and say "yes" if there are no rules or protocols. Implicitly, the person who could give permission also becomes responsible if something goes wrong. Paradoxically, in most situations it is usually much easier to ask for forgiveness than for permission. Thus, we recommend changing the environment first and then asking for forgiveness.

Lack of Somatic Awareness and Training

Most people are unaware of covert low-level muscle tension and only become aware when symptoms or discomfort occur. Many people need to learn to sense lower levels of tension so that they can identify the triggers that precede the development of discomfort. When they can identify the precursors, they are more able to do something about it. They can interrupt the process and hopefully avoid the development of pain and discomfort. When they identify the cue, they can interrupt this pattern and hopefully prevent discomfort. If people wait until they experience symptoms, it is more difficult to reverse the discomfort than if they interrupt the process in the beginning phase, as shown in Figure 3.

Figure 2. Workshop participants rotating their bodies or chairs to perform the group exercise.

The educational and clinical challenge is to teach the participant awareness before symptoms and discomfort occur. Although there are many strategies to teach participants to identify the first behavioral changes that precede the development of the symptoms, one very useful approach is surface electromyographic (SEMG) recording and feedback. Surface electromyography measures the electrical signals that produce skeletal muscle fiber contraction (Cram, Kasman, & Holtz, 1998). The SEMG can provide an objective (third person) perspective of what is actually occurring inside the body and is more accurate than a person's own perception (first person perspective). SEMG is used to demonstrate to people that: (a) they are unaware of low tension levels, and (b) they can learn to increase their awareness by SEMG monitoring and feedback of minimum muscle tension.

In our teaching and clinical experience, neither the participants (student, client, or patient) nor the practitioners (teacher, therapist, coach, or health care provider) can see with their eyes or feel with their hands whether a person's muscles are totally relaxed. Often the visible and tactile experience of minimum muscle tension appears to be the same as being relaxed. In almost all cases, practitioners and participants are surprised to observe the SEMG activity without seeing movement or even feeling tension in the muscles. The SEMG can monitor covert tension and provide feedback to teach an individual to enhance awareness of muscle contraction (Booiman & Peper, 2010). It is not surprising that people are unaware of their muscle tension, because task performance is much more relevant from an evolutionary perspective than how you move the body to perform the task. Seizing the food is much more important for survival than observing how you seize it.

The purpose of this study was to report on a very simple strategy to demonstrate to people that they are initially unaware of low-level muscle tension and that they can learn to increase their body awareness and control.

Method

Participants

The participants were 34 physical therapists (26 females and 8 males; mean age 40.7 years, $SD = 12.7$ years) participating in stress management workshops; participants were skilled in teaching, relaxation techniques, somatic practices, and worksite adjustments.

Equipment and Sensor Location

SEMG was recorded with a single channel electromyography device (MyoTron 120 EMG Set, Enting Instruments, The Netherlands). Surface electrodes were placed over the dorsal surface of the dominant arm over the extensor muscles as shown in Figure 4.

Procedure

After surface electrodes were attached, participants sat comfortably on chairs with their hands on their laps. The participants received no auditory or visual feedback during

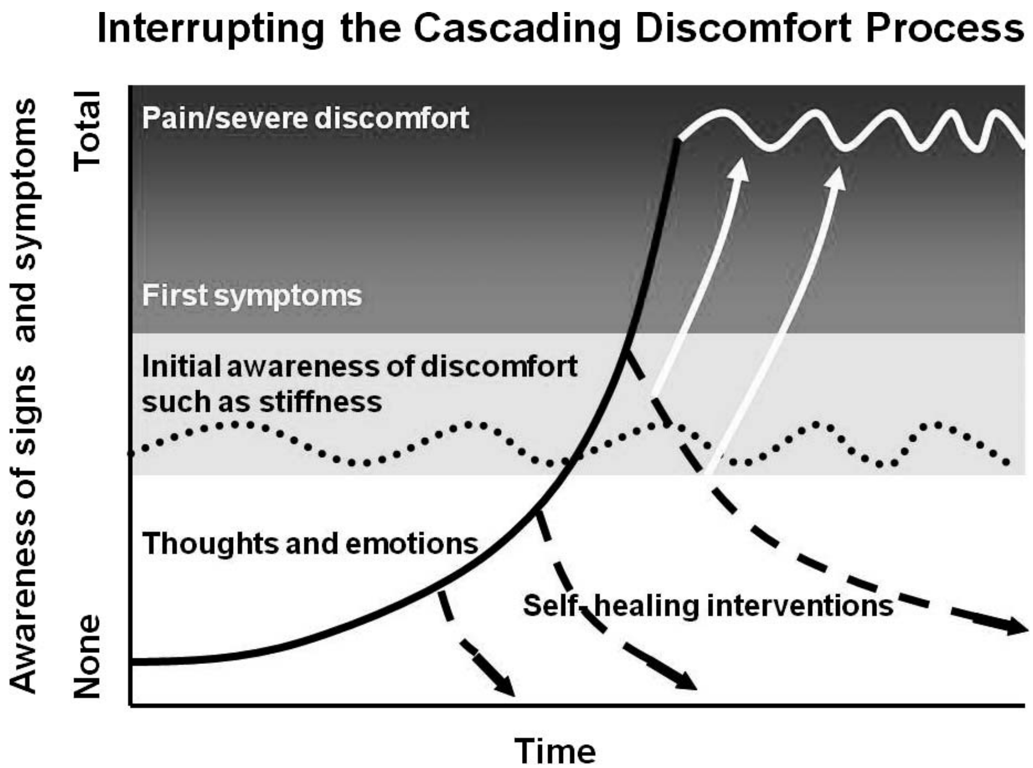

Figure 3. The sooner a person can become aware and begin a self-healing intervention, the more likely the person will be to maintain health and prevent discomfort (area labeled thoughts and emotions). Once the symptoms have developed, it is more challenging to return to health (area labeled initial awareness of discomfort).

the preassessment SEMG recording for the following sequential conditions: (a) relax the arm for 5 to 10 seconds, (b) lift the hand minimally until they became aware of the muscle tension for 5 to 10 seconds, and (c) relax the arm for 5 to 10 seconds.

After performing this task, the participants were shown their own data and then were instructed to use visual digital SEMG feedback to tighten the arm about one half of the previously measured value when they initially lifted their hand, until they became aware of the tension. They practiced for about 5 minutes until they could do this with and without visual feedback. After the participants reported mastery, postassessment SEMG was recorded for the following sequential conditions: (a) relax the arm for 5 to 10 seconds, (b) lift the hand minimally until the person became aware of the muscle tension for 5 to 10 seconds, and (c) relax the arm for 5 to 10 seconds.

Results

All subjects were surprised by how much muscle tension was recorded during the initial minimal tension task. After the short training period, 91% of the participants significantly reduced the minimum SEMG activity. The lowest threshold for awareness of muscle tension during postassessment SEMG following training was significantly lower (9.4 μV) as compared to the preassessment threshold (17.8 μV), $F(1, 64) = 18.95$, $p < .001$, and the prerelaxed condition was significantly lower (1.4 μV) after training as compared to the prerelaxed condition (2.4 μV), $F(1, 64) = 4.03$, $p < .05$, before training as shown in Figure 5.

Discussion

The participants significantly increased their awareness of minimal muscle tension with training, which also significantly decreased the posttraining prerelaxed measure. This simple and quick awareness assessment of minimal tension is a powerful strategy to show to participants that they are unaware of low-level muscle contractions, and that with SEMG biofeedback, they can learn to increase their subjective awareness of lower levels of tension. During the training component, many of the participants reported being totally surprised that the SEMG increased without seeing any visible signs of movement. Others reported surprise that just the intention to initiate movement was enough to increase of SEMG activity. The data and our clinical experience suggest that almost all people can learn to increase their muscle awareness. The observers who collected the data were equally surprised because in many

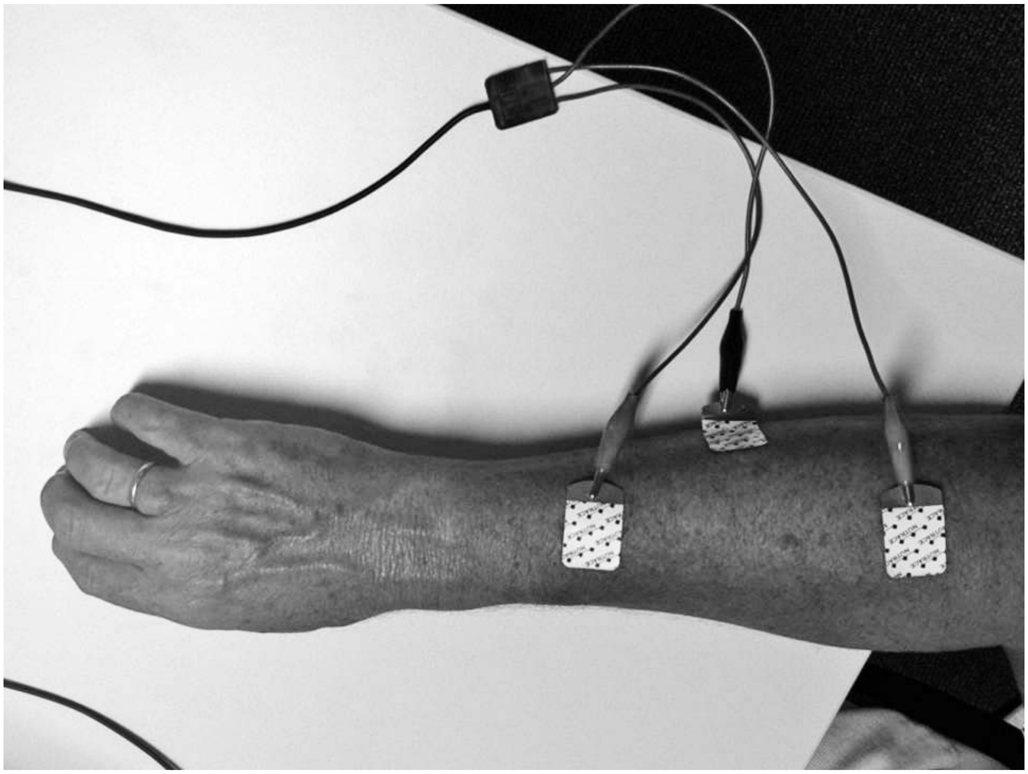

Figure 4. Location of wide electrode placement to monitor the extensor muscles of the forearm.

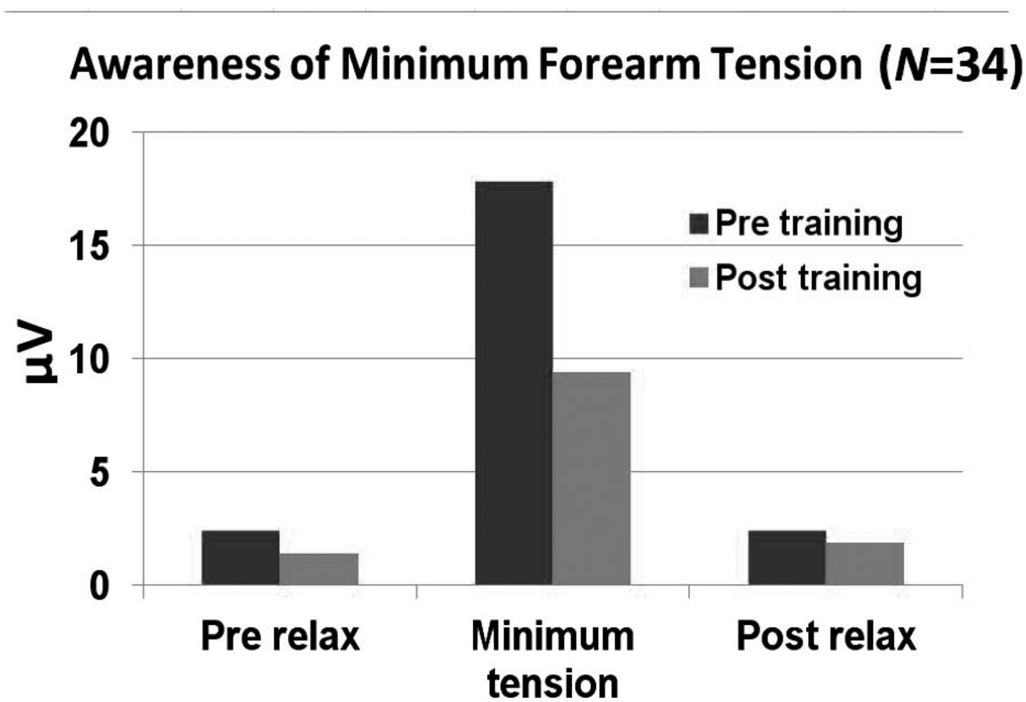

Figure 5. Measurement of forearm extensor muscle awareness of minimum tension before and after feedback training.

cases they noted no change in the body position during the pre- and posttraining phase. They did not see any signs of tension in the posture of the participants even though SEMG activity increased. This study is consistent with prior studies that used EMG biofeedback to reduce musculoskeletal pain and posture correction during computer operation (Levanon, Gefen, Lerman, Givon, & Ratzon, 2012; Park & Yoo, 2012). In addition, Jacobs et al. (2011) used a personal digital assistant (PDA) as an electronic diary to assess discomfort in university students. After seeing the feedback, students increased their awareness, and adjusted the work environment by changing their chair or notebook height.

This simple study has numerous limitations, such as the absence of a control group, no long-term follow-up to monitor whether this learned increase of awareness could be maintained, and no comparisons to other muscle groups. A wide electrode placement does not allow the identification of the specific muscles that caused the increase in SEMG activity. Finally, we did not compare this approach with other relaxation/awareness strategies that might achieve the same results.

Although the limitations are valid, they are not important for the purpose of the study. The goal of this study was to show participants that they were unaware of covert tension and that they could learn to heighten their awareness of muscle tension and reduce this tension within a short time period. This SEMG feedback (numbers and graphs) learning experience was a powerful tool to shift participants' beliefs about illness concepts and encourage them to actively participate in their own self-improvement (Wilson, Peper, & Gibney, 2004). The participants realized that it was possible to think that they were relaxed even though they were still tense. They understood that this covert tension could contribute to their discomfort and would inhibit regeneration. In some cases, they observed that merely anticipating the task caused an increase in muscle tension. That gave them an idea about how they live in their environment—always ready for action.

After participants learned to sense this new lower level of minimum tension, we asked them to identify associated factors (e.g., thoughts, emotions, external triggers, and behaviors) that increased their muscle tension. After identifying those triggers associated with the previous covert muscle tension, they practiced decreasing this tension through various cognitive behavioral approaches, such as relaxing their neck and shoulders, refocusing thoughts on positive images, slow exhalation, and the Quieting Reflex (Stroebel, 1982). In this process, they learned to identify the cues that evoked this tension and strategies to resolve their symptoms. This process is illustrated in the following case example in which the learning of increased muscle awareness was embedded in a broader treatment program. The client used her awareness of previous covert muscle tension to interrupt the tension pattern and prevent discomfort.

Clinical Application

A young woman (25 years) experienced severe pelvic girdle pain after a difficult delivery. Her body posture showed elevated tension, of which she was not aware. After two sessions, which included assessment and cognitive behavioral pain control, the third session included the simple practice of forearm awareness monitoring and training to demonstrate how SEMG displayed the tension in her body. The focus was on the forearm because she tended to clench her fists all the time. Each time she talked about or thought about her pelvic region, her body tension increased as this topic was associated with many emotions. Focusing her attention on her forearm made her more responsive to the information provided by the therapist and the SEMG.

We started the exercise without visible SEMG feedback for the client and just explained the task of minimum muscle tension. Without any awareness on her part, listening to this explanation increased the tension in her forearm (see time point 1 in Figure 6). The therapist then asked her to release her tension, and then asked her to practice the minimum tension task without any visual muscle feedback (see time point 2 in Figure 6).

After the end of the exercise, and seeing the feedback from the screen, which showed the previous SEMG recording and the explanation of the therapist, she was surprised by the SEMG findings and what was happening in her body. She had no idea that her own thoughts during the explanation of forearm tension increased the muscle tension even higher than her deliberate efforts to produce minimum muscle tension. This simple demonstration shifted her belief about the tension she unknowingly built up in her body. It also demonstrated that she could learn control by paying attention to her body and learning to relax. The fact that after the practice, her tension increased again without her feeling it, surprised her and caused the woman to believe that she needed to pay attention to her body for further improvement and healing. This experience became the first step in her starting to do the homework practices to relax her body.

Conclusion

SEMG feedback is a powerful tool to show dysponesis. The SEMG display demonstrates to people that they are

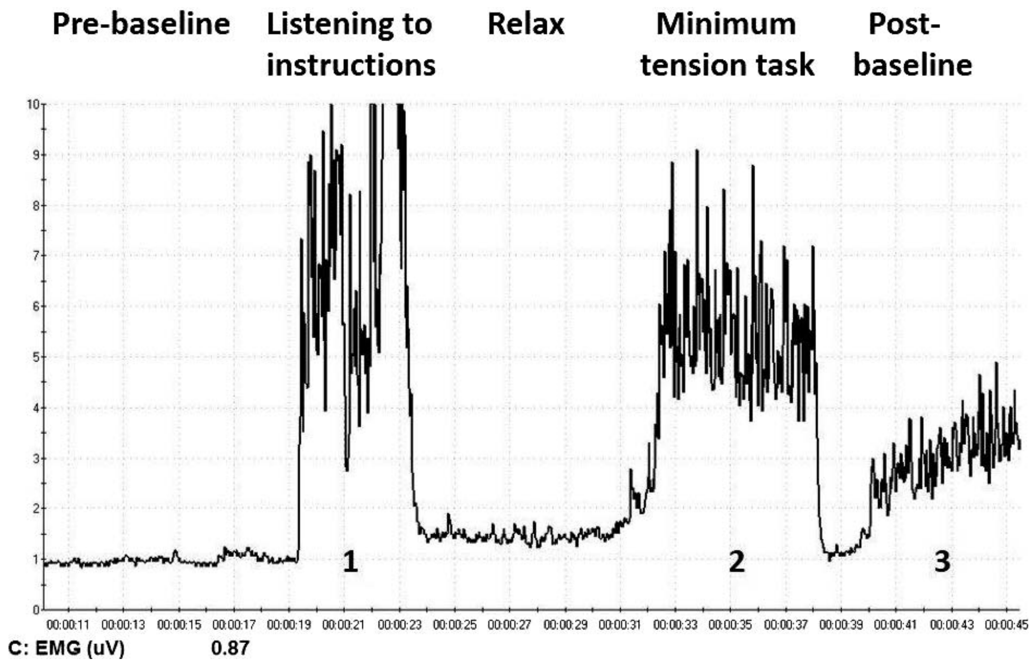

Figure 6. EMG recording from forearm. Epoch 1 shows the muscular response to the initial explanation of forearm tension. Epoch 2 shows the SEMG activity during the actual task of minimum felt muscle tension, and Epoch 3 shows the ongoing muscle tension after the person thought she had relaxed after the minimal tension task.

unaware of covert muscle tension and that they can learn to increase their awareness. This study showed that almost all people can learn to increase their somatic muscle awareness of their forearm. In many cases, we use this as a teaching strategy to point out that the participant's body is covertly reacting to stressors. Clinically, we often repeat this approach with the trapezius muscle of the shoulder because in many cases this muscle group slightly tenses when a person experiences a fight/flight/stress response. Thus, by monitoring their own shoulders and continuously interrupting the bracing, individuals can identify the stressor and develop new coping strategies.

The SEMG feedback transforms the *unfelt* into the *felt* and the *undocumented* into the *documented*. We recommend that this simple strategy of measuring muscle tension awareness and teaching enhanced awareness is a useful tool for teachers, instructors, and health care providers to help participants develop increased awareness.

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